# The fluid definition of the 'waters of the United States': Non-uniform effects of regulation on US wetland protections

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**Abstract**

Recent revisions to the definition of the "waters of the United States" (WOTUS) have considerably altered how wetlands are federally regulated under the Clean Water Act. The two most recent modifications to WOTUS, the Clean Water Rule (CWR) and the Navigable Waters Protection Rule (NWPR), represent two opposing approaches to the federal wetland policy. Despite their implementation, the impacts of these rules on the regulation of wetlands have as of yet been poorly characterized at broad spatial scales. Using New York State (NYS) as a case study, we evaluated the jurisdictional statuses of more than 373,000 wetlands under the CWR and the NWPR to assess the landscape-scale effects of WOTUS re-definitions. We found that statewide and within each of NYS's hydrologic regions, the NWPR protects fewer wetlands and less total wetland area than the CWR. The efficacy of the two regulations varied considerably in space across NYS, highlighting the need for comprehensive, nationwide assessments of wetland policy outcomes. We also observed that both rules produced non-uniform patterns in jurisdiction across a range of landscape positions and wetland sizes, preferentially protecting large wetlands close to the stream network. This effect was particularly pronounced under the NWPR, which excludes all geographically isolated wetlands from protection. Our findings in NYS emphasize the existence of unique patterns in protected wetlands across spatial scales, highlighting the value in applying geospatial analyses to evaluate environmental policy.

## The fluid definition of the 'waters of the United States': Non-uniform effects of regulation on US wetland protections

**Running Title:** Non-uniform impacts of WOTUS regulation

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**Keywords:** wetlands, WOTUS, Clean Water Act, Clean Water Rule, Navigable Waters Protection Rule, regulation, geographically isolated, New York

**Data Availability Statement**

The data that support the findings of this study are openly available in CUASHI Hydroshare (*http://www.hydroshare.org/resource/b9ef542ef9e84ebdad7fe05f0ee95110*).

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Recent revisions to the definition of the "waters of the United States" (WOTUS) have considerably altered how wetlands are federally regulated under the Clean Water Act. The two most recent modifications to WOTUS, the Clean Water Rule (CWR) and the Navigable Waters Protection Rule (NWPR), represent two opposing approaches to the federal wetland policy. Despite their implementation, the impacts of these rules on the regulation of wetlands have as of yet been poorly characterized at broad spatial scales. Using New York State (NYS) as a case study, we evaluated the jurisdictional statuses of more than 373,000 wetlands under the CWR and the NWPR to assess the landscape-scale effects of WOTUS re-definitions. We found that statewide and within each of NYS's hydrologic regions, the NWPR protects fewer wetlands and less total wetland area than the CWR. The efficacy of the two regulations varied considerably in space across NYS, highlighting the need for comprehensive, nationwide assessments of wetland policy outcomes. We also observed that both rules produced non-uniform patterns in jurisdiction across a range of landscape positions and wetland sizes, preferentially protecting large wetlands close to the stream network. This effect was particularly pronounced under the NWPR, which excludes all geographically isolated wetlands from protection. Our findings in NYS emphasize the existence of unique patterns in protected wetlands across spatial scales, highlighting the value in applying geospatial analyses to evaluate environmental policy.

## 1.0 Introduction

Since the expansion of the Clean Water Act (CWA) in 1972, the federal protection of wetlands and rivers in the United States has been governed by the debated and fluid definition of the "waters of the United States" (WOTUS). Wetlands are crucial components of terrestrial landscapes, providing numerous benefits that include biological habitat, floodwater attenuation, biogeochemical processing, and sediment retention (Acreman & Holden, 2013; Capps et al., 2014; Cheng & Basu, 2017; Lane et al., 2018). Despite these widely recognized benefits, wetlands have been disregarded, destroyed, and filled for economic benefit over the past 200 years (e.g., Dahl, 1990; Davidson, 2014; Golden et al., 2019; Hey & Philippi, 1995; Van Meter & Basu, 2015), resulting in subsequent losses of ecosystem services (e.g., Zedler, 2003). Under the CWA, jurisdiction waters (WOTUS) require permits for pollutant discharges, dredging, or filling, while non-jurisdictional waters are afforded no such protections at the federal level. The extent of WOTUS has been ill-defined for more than 50 years, evolving through a series of legal cases and iterative rulemaking that have yielded an operational definition (Walsh & Ward, 2019; Walsh and Ward; In Review). Unlike laws that require legislative initiative, the definition of WOTUS is embedded in the rulemaking process of the executive branch, leaving operational definitions to be established by regulatory agencies (in this case, the USEPA and USACE). Through many high-profile judicial decisions and executive revisions, the extent of WOTUS has seen continual evolution and interpretation (Walsh & Ward, In Review).

The last decade has seen two redefinitions of WOTUS, resulting in significant changes to the federal protection of wetlands in the US. First, the 2015 Clean Water Rule (CWR) attempted to reconcile prior Supreme Court rulings (*United States v. Riverside Bayview Homes* , 1985; S*olid Waste Agency of Northern Cook County v. USACE* , 2001,*Rapanos v. United States* , 2006) into a clear-cut regulatory framework that was both consistent and easily interpretable (USDOD and USEPA, 2015). In addition to protecting intermittent and ephemeral river systems, the CWR classified adjacent waters and wetlands into jurisdictional categories using buffer distances from other protected waters. Leaving room for scientific interpretation, the CWR also codified the "significant nexus test", mentioned in *Solid Waste Agency of Northern Cook County v.*

*U.S. Army Corps of Engineers* (2001) and reaffirmed in Justice Kennedy's concurring opinion in *Rapanos v. United States* (2006). Under the significant nexus test, protections are extended to adjacent water and wetlands on a case-by-case basis if they "significantly affect the chemical, physical, and biological integrity" of adjacent navigable waters, taken alone or in combination with similarly situated waters (*Rapanos v. United States* , 2006). In response to these changes to the WOTUS definition, 31 states and a variety of other plaintiffs pursued legal action to oppose the enforcement of the CWR (e.g., *Georgia v. Pruitt* , 2018;*North Dakota v. USEPA* , 2015; *Texas v. USEPA* , 2018; USDOD and USEPA, 2019). After litigation and numerous preliminary injunctions, the CWR remained enforceable in only 22 US states, including New York (CRS, 2019). A new rulemaking process, intended to revise the CWR, was initiated via executive order in 2017 (Exec. Order No. 13778, 2017).

In 2019, the CWR was repealed and by April of 2020 replaced by the Navigable Waters Protection Rule (NWPR). To promote economic growth and development and to reduce regulatory uncertainty, the NWPR sought to redefine the legal term 'navigable waters' consistent with the opinion authored by Scalia et al. in *Rapanos v. United States* (2006). The NWPR restricted federal protections to waters that contribute flow to a traditionally navigable waterway or sea in a typical year (USDOD and USEPA, 2020). The updated rule also eliminated the significant nexus test, requiring wetlands to receive continuous surface flow from other jurisdictional waters to be considered jurisdictional. This redefinition of WOTUS under the NWPR was vacated by *Pasqua Yaqui Tribe v. USEPA (2021* ). With the CWR repealed and NWPR struck down, federal wetland protections in the US have presently reverted to the regulations codified by the USEPA and USACE in 1986 (USDOD, 1986), though new rulemaking has been initiated (USDOD and USEPA, 2021).

Given the recency and fluidity of ongoing revisions to US federal water policy, few studies have assessed how the evolving definitions of WOTUS have altered the protection of wetlands (Sullivan et al., 2020). While a limited number of past studies have considered the protection of wetlands at the watershed scale (Walsh & Ward, 2019; Meyer & Robertson, 2019), additional work is still needed to characterize the complex implications of these changes to federal water policy, as the services provided by wetlands are non-uniform and vary considerably as a function of spatial location (Cohen et al., 2016; Lane et al., 2022; Marton et al., 2015) and size (Cheng & Basu, 2017; Ghermandi et al., 2010). This need is even more pressing given that the USEPA and USACE have indicated that a WOTUS revision will occur in the near future (USEPA, 2021). Thus, our objective in this study is to document how changes to the legal definition of WOTUS under the CWR and NWPR alter which wetlands are protected as a function of their landscape position and size. To achieve this objective, we use the wetland-dense state of New York (NYS) as a case study to demonstrate how changing regulatory language can yield patterns of protection that are biased against particular types of wetlands. Through regional analysis, we contribute to the evolving discourse assessing the implications of WOTUS definition revisions for wetland protections. We also provide additional discussion to contextualize the controversial nature of federal wetland protection and policy amongst numerous competing interests.

## 2.0 Methods

To date, few studies have investigated how the regulatory shift from the CWR to the NWPR has impacted US watersheds (Meyer & Robertson, 2019; Walsh & Ward, 2019; Walsh and Ward, In Review). We take NYS as a case study (Figure 1), providing an assessment in the northeastern US that spans multiple ecoregions and drains to multiple endpoints (including the Great Lakes, Susquehanna and Delaware River basins, and the Atlantic Ocean). The approach used in this study, following prior work of Walsh & Ward (2019, In Review) and Meyer & Robertson (2019), leverages several publicly available datasets to classify the jurisdictional status of wetlands in New York. We quantified the federal protections of more than 373,000 non-marine wetlands present in the US Fish and Wildlife Service's National Wetland Inventory (NWI), covering over 876,000 ha across the state of New York (U.S. Fish and Wildlife Service, 2021). We excluded wetlands classified as estuarine or marine in NWI records. Wetlands smaller than 0.01 ha in size were also omitted from further analysis. We selected this threshold to minimize the inclusion of small wetland fragments adjacent to larger contiguous wetland polygons. We summarize wetland protection statuses state-wide and at a smaller regional scale (defined by USGS HUC–6 basins; Figure 1). Given that most investigations of wetland policy are performed at the watershed scale, our analysis allows for an evaluation of policy outcomes across a range of broader spatial scales.

As the jurisdictional status of wetlands primarily stems from their proximity to streams, the identification of the location of the stream network is a key task in the evaluation of WOTUS protections. Previous approaches (e.g., Walsh & Ward, 2019) used topographically-based flow accumulation methods to estimate the spatial extent of the stream network. We instead chose to define the stream network using the USGS National Hydrography Dataset (NHD; 1:24,000 scale, Model Version 2.2.1), as we could not ensure the reliability and accuracy of a topographically-generated network at the geographic scale of NYS (U.S. Geological Survey, 2020). While the NHD may underestimate stream network extent (Elmore et al., 2013), the NHD does provide a consistent and validated record of the location of streams within our study area and across most regions in the US (Meyer & Robertson, 2019). We used NHD waterways as the basis for the location of the stream network in both the CWR and NWPR scenarios. This may result in a conservative estimate of the jurisdictional stream network under the CWR as the version of the NHD used here only maps perennial and intermittent streams in NYS (U.S. Geological Survey, 2020). Thus, we assume the NHD network is representative of the network with flow during a typical year for the NWPR scenario and serves as a conservative lower bound for the stream network in the CWR scenario.

To define the protection status of each wetland within NYS, we translated the regulatory procedures of the CWR and NWPR into a set of geospatial analysis steps within ArcGIS Pro (Version 2.6.0). Using this process, we classified each NWI wetland as jurisdictional, non-jurisdictional, or requiring the application of the significant nexus test (abbreviated as 'significant nexus') for each regulation based on the spatial relationships of each wetland to the stream network. Under the CWR, wetlands located (1) within 100 ft (30.5 m) of a jurisdictional water, (2) within both 1500 ft (457.2 m) of a jurisdictional water and the 100-year floodplain, or (3) within 1500 ft (457.2 m) of a traditionally navigable waterway are considered jurisdictional by rule. As US wetland regulations are based around imperial system units, we report these values first, followed by SI units in parentheses. We applied a spatially continuous floodplain map (Woznicki et al., 2019) to estimate the location of the 100-year floodplain in our study area, as the commonly used Federal Emergency Management Agency (FEMA) floodplain dataset was incomplete across NYS. To identify the extent of traditionally navigable waterways, we used publicly available streamflow information and channel geometry from the USGS to create discharge-depth regression relationships across New York State. We defined 'traditionally navigable' waterways as those receiving at least a median of 0.30 m of inundation per year (following Walsh and Ward, 2019). All wetlands that do not satisfy the aforementioned jurisdictional criteria but are located within 4000 ft (1219.2 m) of another jurisdictional water are subject to the significant nexus test under the CWR. Given the challenge in applying the case-by-case significant nexus test to broad spatial scales, we were unable to determine the precise extent of jurisdictional wetlands when evaluating the CWR. Instead, depending on the results of site-specific significant nexus determinations made by the USEPA and USACE, the percentage of jurisdictional wetlands under the CWR may vary considerably. Wetlands located further than 4000 ft (1219.2 m) away from a jurisdictional water are considered non-jurisdictional by rule and are afforded no protection by the CWR. While not directly assessed in this study, the CWR also considers the impacts of 'similarly situated waters', effectively assessing aggregate impacts from several wetlands.

In contrast to the buffering approach used by the CWR, the NWPR defines protections based on a surface-water connection between wetlands and the jurisdictional stream network. The rule eliminates the significant nexus test, instead classifying wetlands as either jurisdictional or non-jurisdictional. For the NWPR scenario, wetlands were considered jurisdictional only if they directly intersected the jurisdictional stream network, simulating a surface-water connection. While we acknowledge that this intersection approach does not necessarily guarantee federal jurisdiction based on the NWPR, as we cannot confirm a continuous surface connection at the scale of this analysis, we take this as a reasonable estimate for protection.

## 3.0 Results

### 3.1 The NWPR Decreases Wetland Protections Across NYS Compared to the CWR

In NYS, the NWPR guarantees protections for considerably fewer wetlands by both total area and number when compared to the CWR (Figure 2). Under the CWR, 88.3% of total wetland area was considered jurisdictional by rule, 11.7% of wetland area required further evaluation through the significant nexus test, and less than 0.1% of wetland area was non-jurisdictional. In contrast, the NWPR reduced the area of jurisdictional wetlands to 78.1%, leaving 21.9% of New York's wetland area non-jurisdictional by rule. The CWR has the potential to protect up to a maximum of 99.9% of wetland area, though the true magnitude of protections is dependent on the site-specific evaluation of the significant nexus test. We estimate that the NWPR decreases jurisdictional wetland area by 11.6% as compared to the CWR state-wide, resulting in a loss in protection for at least 89,000 ha of wetlands in NYS. Additional wetland losses, though unquantified in this study, are likely, given the NWPR's elimination of the significant nexus test.

Across New York's 16 USGS HUC6 basins, we found that federal wetland protections varied considerably in space (Figure 2). Between hydrologic basins, CWR jurisdictional wetland area varied from a minimum of 76.5% (HUC 041201) to a maximum of 97.4% (HUC 020302). NWPR jurisdictional wetland area ranged between a minimum of 55.3% (HUC 041201) and a maximum of 86.6% (HUC 020301). We also observed substantial spatial variability in shifts in legal protections from the CWR to the NWPR across basins. For example, the replacement of the CWR by the NWPR resulted in a 27.5% loss of jurisdictional wetlands area in HUC 042701, but only a loss of 4.4% in HUC 020401.

### 3.2 Federal Wetland Protections Vary as a Function of Wetland Size and Landscape position

Wetlands are unevenly distributed across the landscape, both in terms of individual wetland size and the position of wetlands in relation to stream networks. The size-frequency relationship of wetlands tends to follow a power-law distribution, with smaller wetlands occurring orders of magnitude more frequently on the landscape than comparatively larger wetlands (Van Meter & Basu, 2015). This relationship holds for NYS, where 73.2% of unique wetlands are smaller than 1 ha in size (Figure 3). However, while the majority of New York wetlands are relatively small, the largest proportion of total wetland area is concentrated amongst a limited number of large wetlands. Although wetlands larger than 30 ha make up only 1.1% of NYS wetlands by number, they represent 44.2% of total wetland area (Figure 3).

The position of wetlands in relation to the nearest jurisdictional water also follows a skewed distribution (Figure 3). Of NYS's wetlands, 52.8% of unique wetlands and 84.7% of total wetland area are located within 100 ft (30.5 m) of the stream network. We also observe that wetlands located at greater distances from the stream network tend to be smaller in area than those positioned near streams (Figure 4). While most of New York's wetlands are relatively small and located across a wide range of distances from the stream network, the majority of total wetland area is concentrated near the stream network, contributed by large wetlands.

We observe that both the CWR and NWPR preferentially protect wetlands in close proximity to the stream network, though this phenomenon is more pronounced for the NWPR (Figure 4). Within 100 ft (30.5 m) of the stream network, the CWR protects 100% of NYS wetlands by rule, representing over 740,000 ha of total wetland area. Of wetlands located between 100 and 4000 ft (30.5 and 1219.2 m) from streams, 14.1% of unique wetlands (23.4% of total area) are afforded jurisdictional status by the CWR while the remaining 85.9% of unique wetlands (76.6% of total area) require further evaluation under the significant nexus test. With its requirement of a surface-water connection, the NWPR considerably narrows the extent of protected wetlands toward the stream network. In direct comparison to the CWR, the NWPR protects only 74.4% of wetlands (92.1% of total area) within 100 ft (30.5 m) of the jurisdictional stream network and no wetlands outside of 100 ft (30.5 m). Despite these decreases, the NWPR still protects roughly 690,000 ha of wetlands within 100 ft (30.5 m) of the stream networks.

Coupled with the distribution of wetlands on the landscape, these geographic patterns result in distinct biases in the sizes of wetlands conserved (Figures 4 and 5). Under both rules, larger wetlands are considerably more likely to be classed as jurisdictional, while comparatively smaller wetlands tend to fall into the significant nexus or non-jurisdictional categories. Of wetlands larger than 30 ha, 99.0% and 96.2% of wetland area are jurisdictional under the CWR and NWPR, respectively. By comparison, wetlands smaller than 1 ha received markedly less protection, with only 57.8% and 36.9% of wetland area considered jurisdictional by rule under the CWR and NWPR, respectively. With decreasing wetland size, wetlands become increasingly dependent on the CWR significant nexus test to receive legal protection (Figure 5). Roughly 43% of wetlands smaller than 1 ha required the application of the significant nexus test under the CWR, compared to 0.99% of wetlands larger than 30 ha. We note that this size bias has little effect on the total area of wetlands protected, as small but numerous wetlands contribute a relatively small proportion of wetland area.

## 4.0. Discussion

### 4.1. What are the Implications of Changing Regulations for Wetland Protection in NYS?

The CWR and NWPR's contrasting approaches to wetland protection result in clear disparities in the protection of wetlands. Across all hydrologic regions of NYS, the NWPR consistently protects fewer wetlands by both total area and number compared to the CWR (Figure 2). This finding is in close agreement with other studies that document decreased protections for wetlands moving from the CWR to NWPR at both state and watershed scales (Meyer & Robertson, 2019; Mihelcic & Rains, 2020; Walsh & Ward, 2019). The consequences of the NWPR on wetland protections are two-fold. First, the NWPR's strict requirement of a surface-water connection between a wetland and another jurisdictional waterway, replacing the CWR's framework of buffer distances, severely limits the total area of wetlands protected (Figure 2). Compounding those losses, the removal of the significant nexus test under the NWPR eliminates potential protections for a diverse subset of wetlands located at distance from the stream network. While the NWPR claims to simplify wetland regulation, it does so at the expense of lost protections for many NYS wetlands.

In NYS, we also observed considerable heterogeneity in wetland protections across hydrologic regions (Figure 2). Although statewide statistics of protection can be informative in the aggregate, they mask a wider range of extreme outcomes at smaller spatial scales. Between individual hydrologic regions of NYS, we found that the percent of jurisdictional area protected under the CWR and NWPR varied by up to 20.9% and 31.3%, respectively. This result emphasizes that federal regulations generate considerable spatial non-uniformity in wetland protections. Indeed, our documentation of spatial inconsistencies in protections highlights that the conservation of wetlands is a strongly regional issue. The efficacy of wetland regulation is likely tied to the distribution of wetlands on the landscape, which is controlled by gradients in topography, geology, subsurface flow, and climate at regional to continental scales (e.g., Bertassello et al., 2020). The patterns of wetland protection in New York, a state that spans a variety of Northeastern ecoregions, cannot be easily extrapolated to other areas of the US with dissimilar landscape characteristics and wetland distributions. This regional heterogeneity underscores the need for additional analyses of wetland policy in other diverse ecoregions of the US, furthering a more geographically comprehensive understanding of the implications of regulation.

### 4.2 Biases in Protection: Which Wetlands Do Our Regulations Ignore?

The regulatory approach taken by the NWPR, centered around the criteria of surface-water connection, contracts the distribution of protected wetlands inwards towards the stream network and exacerbates historical trends in upland wetland loss (Van Meter & Basu, 2015). By requiring a connection between surface waters and wetlands, the NWPR introduces a strong bias against small, geographically isolated features. However, as a considerable proportion of NYS's wetland area is concentrated in large wetlands near the stream network (Figure 2), the NWPR's spatial constriction of regulations has an undersized impact on the total area of wetlands protected (Figure 4). While the CWR has a similar (though less severe) jurisdictional bias against small wetlands, the existence of the significant nexus test may serve to protect upload wetlands, especially as wetland size decreases (Figure 5). The elimination of the significant nexus test by the NWPR entirely omits protections for these smaller, distal wetlands.

Although the NWPR results in a mere 11.6% decrease in jurisdictional wetland area compared to the CWR, its strong bias against geographically isolated wetlands could result in outsized impacts on water quality, nutrient cycling, and other ecosystem services (Cohen et al., 2016; Sullivan et al., 2019, 2020). Small, isolated wetlands cycle nutrients, carbon, and pollutants at disproportionately high rates due to their ratio of reactive area to storage and their long residence times (Cheng & Basu, 2017; Ghermandi et al., 2010; Marton et al., 2015). These wetlands do not meet the criteria for protection under the NWPR, yet they are undoubtedly linked to the quality of downstream waters through hydrological and biogeochemical exchanges along slower subsurface flow paths (USEPA, 2015; Cohen et al., 2016). The heterogeneous aquatic habitats provided by isolated wetlands also facilitate biological connectivity across the landscape, enabling regional species dispersal and enhancing spatial biodiversity (Cohen et al., 2016; Scheffer et al., 2006).

The NWPR represents a clear step towards a more homogeneous wetlandscape. While the CWR attempts to protect wetlands spanning a wide range of sizes and landscape positions, the NWPR takes a contrasting regulatory approach, focusing protections on (larger) wetlands near the stream network. These floodplain wetlands undoubtedly provide extensive benefits such as peak flow attenuation (Ameli & Creed, 2019). However, concentrating protections on floodplain wetlands alone could critically threaten the multitude of ecosystem services provided by isolated, upland wetlands. Non-floodplain wetlands are inherently heterogeneous, spanning broad spectrums of size, shape, landscape position, connectivity, and hydrologic residence time (Evenson et al., 2018; Golden et al., 2019). The cumulative landscape effects of these diverse and often isolated wetlands are integral to watershed-scale resilience, contributing resistance to regime change instigated by hydrological, biogeochemical, and anthropogenic disturbances (Golden et al., 2021; Lane et al., 2022). By specifically targeting upland wetlands, the implementation of regulatory strategies akin to the NWPR could result in considerable negative impacts on downstream water quality, including increased peak discharges, sediment and nutrient loading, and eutrophication (Lane et al., 2022; Yang et al., 2010).

### 4.3. Challenges and Opportunities in Translating Federal Policy into Quantitative Landscape Impacts

Overall, the development of federal wetland policy is underlain by an inherent tension between the recognized economic and environmental benefits of wetlands and the costs of regulation (Boyle et al., 2017). Although the preservation of a diverse suite of wetlands may ensure that a complete set of ecosystem services is maintained, we acknowledge that striving for policy that is clear, efficient, and interpretable is equally desirable (Mihelcic & Rains, 2020). Above all, regulations that contain definitions such as WOTUS often require interpretation by scientists and regulators, and consistent and clear guidelines can help to reduce uncertainty and make enforcement more efficient. While geospatial analyses such as this study can provide initial evaluations of policy outcomes, the translation of regulations into quantitative assessments of landscape impacts often requires more detailed and site-specific approaches. The implementation of Clean Water Act protections has long relied upon boots-on-the-ground assessments, and no amount of geospatial data can substitute for case-by-case field studies. Still, we assert that while regulatory determinations based on spatial data may be imperfect, broad-scale geospatial evaluations of wetland policy still provide considerable utility. Such approaches can be used to make a significant proportion of preliminary assessments of wetland jurisdiction, providing substantial benefits to regulators and landowners alike. While wetland-by-wetland assessments may be more accurate in determining the regulatory status of individual waters, geospatial analyses are still needed to capture complex and non-uniform regional patterns in protections across the landscape.

Despite the unique advantages provided by broad-scale assessments of wetland policy, we also acknowledge that such approaches are limited by imperfections inherent to all types of geospatial data. In wetland inventories, the extent of vulnerable non-floodplain wetlands is often insufficiently mapped due to their small size and dynamic state (Lane et al., 2022). Similarly, existing datasets representing the stream network at regional and broader scales are known to conservatively estimate river network extent (Elmore et al., 2013). Likewise, the location and extent of the stream network, which presently determines wetland protections under the CWA, expands and contracts seasonally and from year to year, making it difficult to map streams effectively (Godsey & Kirchner, 2014; Ward et al., 2018). Wetland locations and their connectivity to adjacent waters are also uncertain and prone to variations on a seasonal basis due to shifts in annual weather conditions and impacts from human activity. In aggregate, these uncertainties demonstrate that a combination of field evidence and professional judgment is still required to evaluate the regulatory status of a particular wetland. Regardless of these challenges, data-driven investigations such as the one presented here are a necessary step to ensure that we understand how the policies of today will impact the landscapes of the future (Mihelcic & Rains, 2020).

With yet another WOTUS revision on the horizon (USDOD and USEPA, 2021), it is a crucial time to consider the implications of existing science and to evaluate how changes to federal regulations will impact wetland protections and the environment at large. While the effects of recent WOTUS iterations have been assessed across several watersheds (Meyer & Robertson, 2019; Walsh & Ward, 2019), our understanding of the potential country-wide impacts of regulations such as the NWPR is worryingly deficient (Sullivan et al., 2020). Our findings of non-uniformity in the protection of wetlands across hydrologic regions, landscape positions, and wetland sizes indicate that the impacts of regulation are too complex to be extrapolated from studies at individual watersheds. Current and future wetland policy must be assessed at a national level to ensure that regulations uphold the CWA's goal of maintaining the chemical, physical, and biological integrity of US waters (Federal Water Pollution Control Act Amendments, 1972). By investigating regulatory impacts at a continental scale, rather than generalizing from local-scale case studies, policymakers can ensure that wetlands receive equitable protections across the many diverse ecoregions of the US.

## 5.0. Conclusion

The regulatory definition of WOTUS has been the source of a litany of lawsuits and repeated debates over rulemaking related to federal wetlands protection. While interpretations of environmental policy will always require judgment on a case-by-case basis, analyses like ours present a broad-scale assessment of the changes that will be realized on the landscape as a function of changing federal rules. Key findings of our study include:

- In comparison to the CWR, the NWPR decreases the total area and number of wetlands protected in New York State. State-wide, we estimate that the NWPR protects 11.6% less total wetland area than the CWR, with a potential for greater losses in protection depending on the evaluation of the CWR's significant nexus test.
- The impacts of regulatory change on wetland protections are highly variable across regions (e.g., HUC-by-HUC differences within a single state as shown here). As such, we discourage the extrapolation of watershed-scale policy outcomes to broader regions and suggest that a comprehensive approach is necessary to understand regulatory impacts.
- Federal wetland regulation can result in a non-uniform distribution of protections across the landscape. With its use of a surface water connection as criteria for jurisdiction, the NWPR preferentially protects larger wetlands close to the stream network, leaving smaller and more geographically isolated wetlands particularly vulnerable. The loss of these unprotected, non-floodplain wetlands could result in a considerable decline in ecosystem function, given their unique biological and chemical functions.

## 6.0. References

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**Figure Captions:**

**Figure 1.** Distribution of 373,000 non-marine wetlands in New York State as recorded by the National Wetland Inventory. Within each of New York's 16 HUC6 basins, the jurisdictional status of wetlands was assessed based on proximity to the stream network derived from the National Hydrography Dataset. Inset displays the spatial relationship between wetlands and the stream network within a single basin.

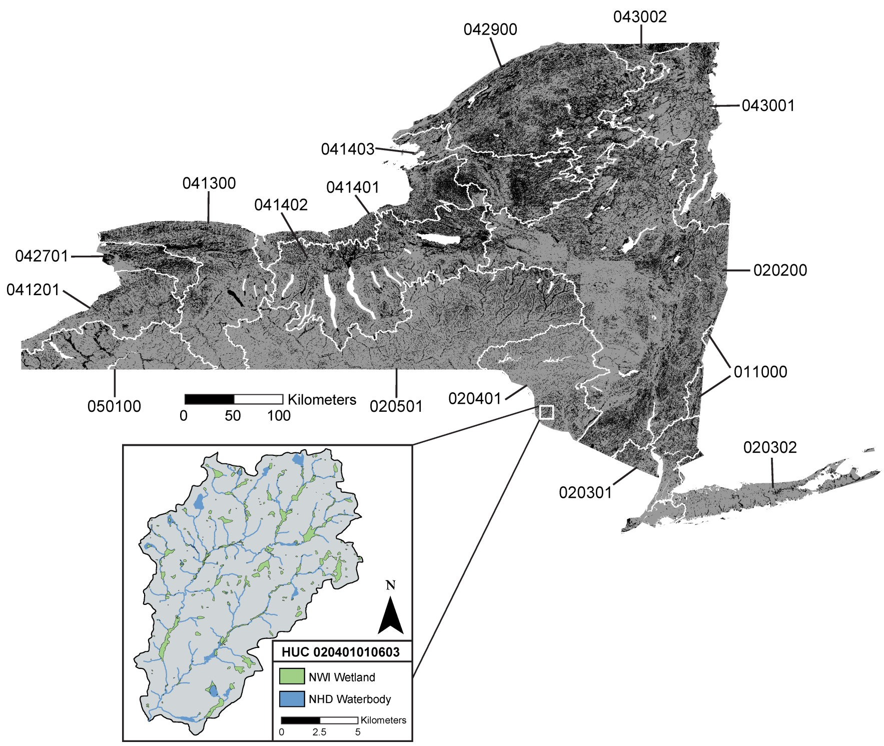
**Figure 2.** Percentage of wetland area guaranteed jurisdictional status under the CWR and NWPR statewide and within each of New York's HUC6 basins. Values to the right of bars indicate the percent change

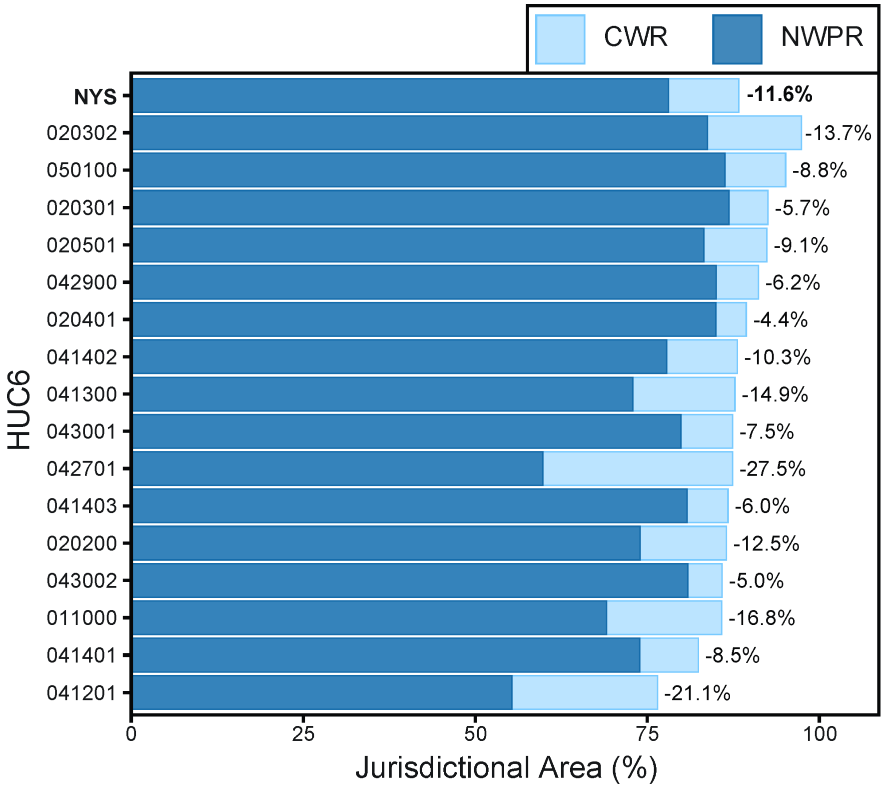
in jurisdictional wetland area from the CWR to the NWPR scenarios.

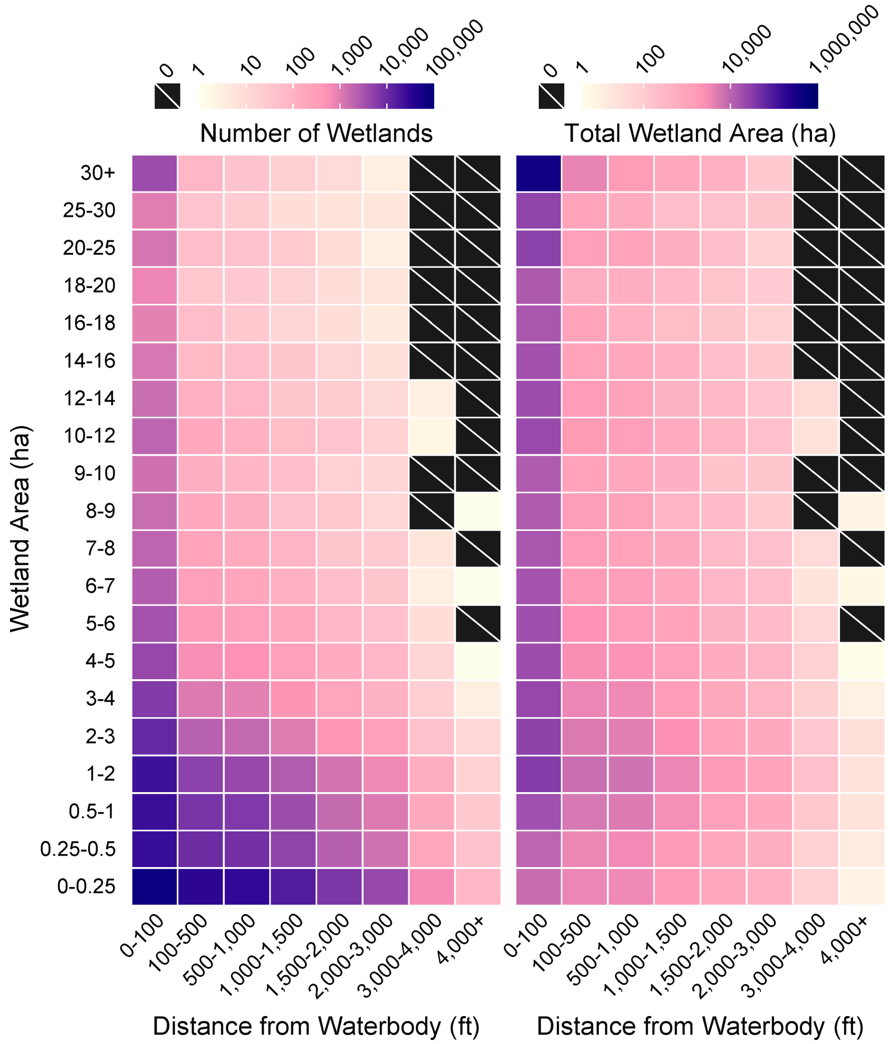
**Figure 3.** Relationship between wetland area and proximity to the nearest jurisdictional water. Wetlands were grouped into bins of areas and distances to evaluate their distribution on the landscape with respect to both the number of unique wetlands and total wetland area. Zero values indicate that no wetlands fell within that particular area and distance range.

**Figure 4.** Wetland protection statuses under the CWR and NWPR as they relate to wetland size and landscape position. Wetlands can receive protection under the CWR by either being jurisdictional by rule (leftmost panels) or through the application of the significant nexus test (center panels). Under the NWPR, wetlands may only receive legal protection if they are jurisdictional by rule (rightmost panels). The percent of wetlands protected is calculated based on the proportion of unique wetlands within each size-distance bin that are classified into each regulatory category (top panels). Total area protected reflects the sum of wetland area within each size-distance bin for a particular regulatory category (bottom panels). NA values indicate that no wetlands fell within that particular area and distance range.

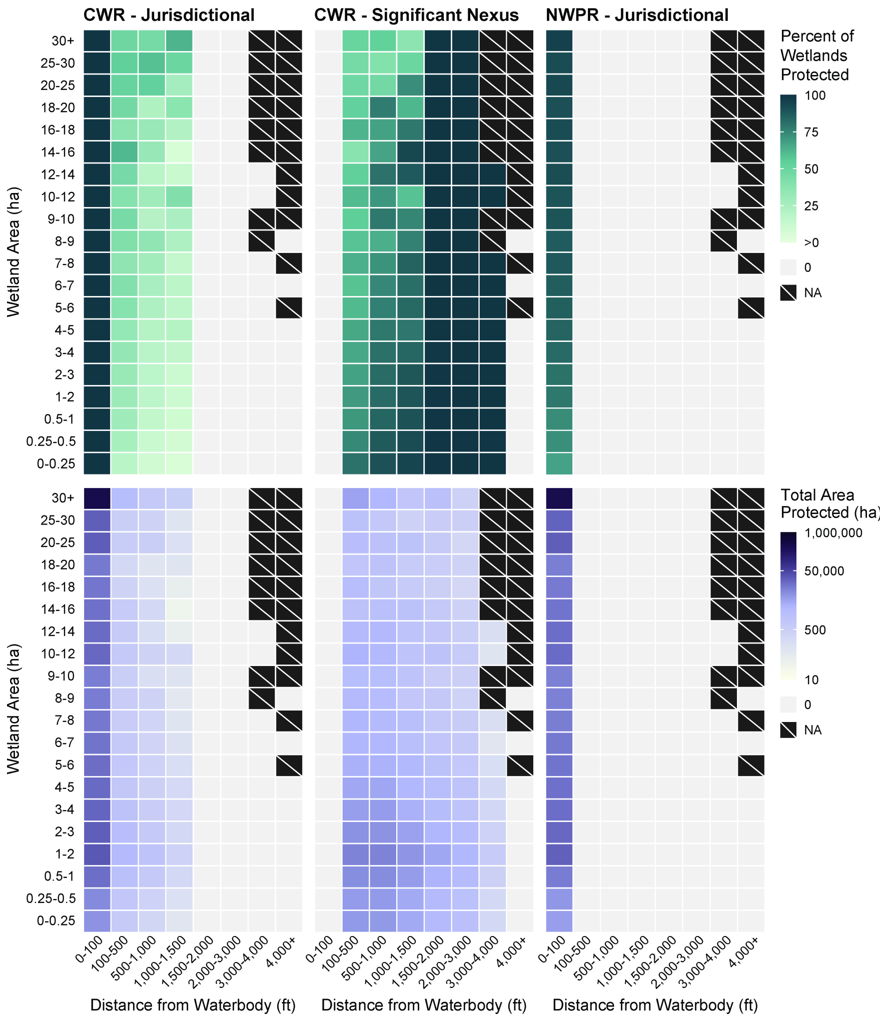
**Figure 5.** Percentage of wetland area protected within ranges of wetland sizes under the NWPR and the CWR. Given the uncertainty in the regulatory status of wetlands requiring the application of the CWR's significant nexus test, CWR protections may vary considerably, up to a maximum jurisdictional percentage (CWR Max Jur.) equal to the sum of jurisdictional area (%) and significant nexus area (%).

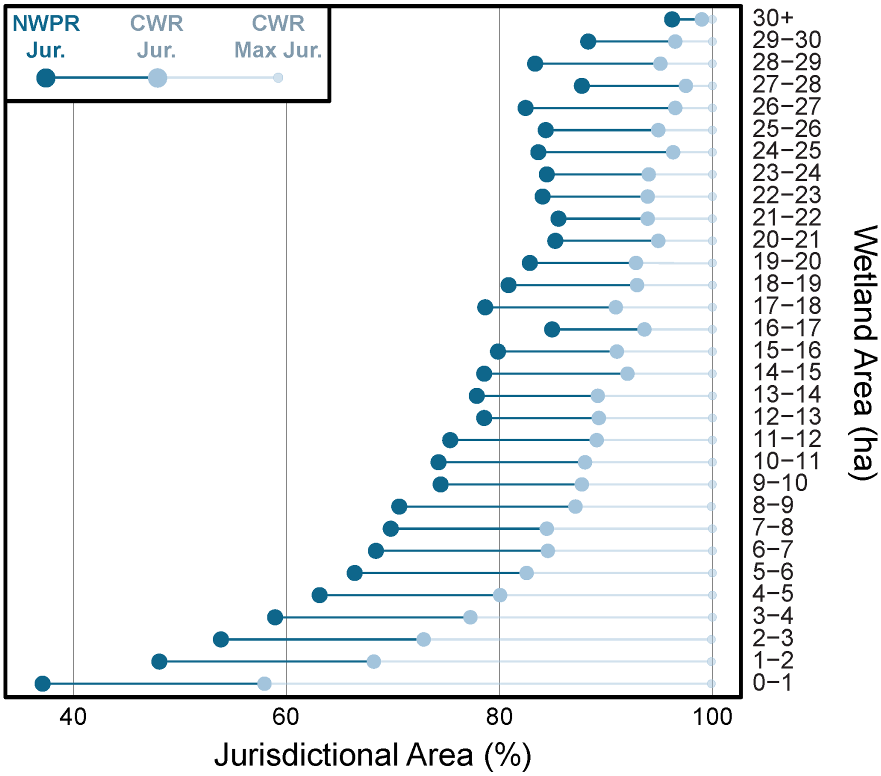



CWR
NWPR
HUC6
NYS
020302
050100
020301
020501
042900
020401
041402
041300
043001
042701
041403
020200
043002
011000
041401
041201
-11.6%
-13.7%
-8.8%
-5.7%
-9.1%
-6.2%
-4.4%
-10.3%
-14.9%
-7.5%
-27.5%
-6.0%
-12.5%
-5.0%
-16.8%
-8.5%
-21.1%
0
25
50
75
100
Jurisdictional Area (%)



0
1
10
100
1,000
10,000
100,000
Number of Wetlands
0
1
100
10,000
1,000,000
Total Wetland Area (ha)
Wetland Area (ha)
30+
25-30
20-25
18-20
16-18
14-16
12-14
10-12
9-10
8-9
7-8
6-7
5-6
4-5
3-4
2-3
1-2
0.5-1
0.25-0.5
0-0.25
0-100
100-500
500-1,000
1,000-1,500
1,500-2,000
2,000-3,000
3,000-4,000
4,000+
Distance from Waterbody (ft)
Distance from Waterbody (ft)


CWR - Jurisdictional
CWR - Significant Nexus
NWPR - Jurisdictional
Percent of Wetlands Protected
100
75
50
25
>0
0
NA
Total Area Protected (ha)
1,000,000
50,000
500
10
0
NA
Wetland Area (ha)
30+
25-30
20-25
18-20
16-18
14-16
12-14
10-12
9-10
8-9
7-8
6-7
5-6
4-5
3-4
2-3
1-2
0.5-1
0.25-0.5
0-0.25
0-100
100-500
500-1,000
1,000-1,500
1,500-2,000
2,000-3,000
3,000-4,000
4,000+
Distance from Waterbody (ft)


NWPR Jur.
CWR Jur.
CWR Max Jur.
30+
29−30
28−29
27−28
26−27
25−26
24−25
23−24
22−23
21−22
20−21
19−20
18−19
17−18
16−17
15−16
14−15
13−14
12−13
11−12
10−11
9−10
8−9
7−8
6−7
5−6
4−5
3−4
2−3
1−2
0−1
Wetland Area (ha)
40
60
80
100
Jurisdictional Area (%)